PART 3

LEVEL 1 MODELS

Chapter 4. MICHTOX Food Chain Modeling

MICHTOX is a toxic chemical mass balance and bioaccumulation model. The model was used at the beginning of the Lake Michigan Mass Balance Project (LMMBP) as a planning tool (Endicott *et al*., 2005). After the LMMBP data were collected, the model provided preliminary mass balance modeling assessments for polychlorinated biphenyls (PCBs) in Lake Michigan (Endicott, 2005). For the present phase of the LMMBP, MICHTOX was used to provide a screening-level analysis of the effects of various pollutant loading sources on bioaccumulation in Lake Michigan lake trout, and to predict the length of time until PCB concentrations in lake trout declined below health advisory target levels under different forecast scenarios. Chapter 4 discusses this aspect of the MICHTOX application. MICHTOX also provided a comparison of an established "off-the-shelf" model to the more complex Level 2 models developed during the LMMBP.

MICHTOX contains both a fate and transport submodel and a food chain bioaccumulation submodel. This chapter provides information on the application of the MICHTOX food chain bioaccumulation submodel to Lake Michigan. The food chain submodel is briefly described, with a complete description included in Endicott *et al*. (2005). The model coefficients and data are also briefly described. The remainder of the chapter includes a discussion of seven model scenarios that were conducted as a screening-level assessment of the fate and sources of PCBs in the system, as a preliminary evaluation of the potential range of future PCB concentrations in Lake Michigan under different possible loading scenarios, and for a comparison to predictions of the Level 2 models.

3.4.1 Model Development

MICHTOX was originally developed in the early 1990s as a screening model for the Lake Michigan Lake-wide Management Plan (LaMP) and for development of the LMMBP (Endicott *et al*., 2005). The model was later updated with newer process formulations, parameters, and the LMMBP data (Endicott, 2005), as described in Part 3, Chapter 3.

The screening-level food chain bioaccumulation modeling for Part 3 was completed using the food chain submodel of MICHTOX. This submodel was essentially unchanged from the original version (Endicott *et al*., 2005), except for adaptations to the program code to accommodate 62-year model runs for the forecast modeling.

The MICHTOX food chain bioaccumulation submodel was adapted from version 3.20 of the Manhattan College Food Chain Model, which was based upon the WASTOXv4 food chain model (Connolly and Thomann, 1985; Connolly, 1991). It used the time-variable water column dissolved and particulate PCB concentrations output from the MICHTOX fate and transport submodel as the PCB exposure concentrations for the trophic levels of the food chain. The MICHTOX food chain submodel was applied separately to paired water column and sediment segment output from the fate and transport submodel for each area of interest. As with the fate and transport submodel, the food chain submodel simulated total PCBs as the sum of two homologs: tetrachlorobiphenyl (PCB4) and pentachlorobiphenyl (PCB5).

MICHTOX treats bioaccumulation as a chemical mass balance within individual organisms, and a bioaccumulation differential equation was solved for each individual age class of organism (Equation 3.4.1) (Endicott *et al*., 2005):

$$\frac{dv_i}{dt} = k_{ui}\, c\, f_d + \sum_{j=1}^{n} p_{ij}\, \alpha_{ij}\, C_{ij}\, v_j - K'_i\, v_i \qquad (3.4.1)$$

where

i = the organism of interest

j = the prey organism

v_i = chemical concentration in organism i (M_{chem}/M_{wet})

k_{ui} = uptake rate ($L^3/T/M_{wet}$)

c = chemical concentration in water (M/L^3)

f_d = dissolved chemical fraction in the water column

p_{ij} = feeding preference factor $\sum_{j=1}^{n} (p_{ij} = 1)$ of organism i for organism j

α_{ij} = chemical assimilation efficiency across gut

C_{ij} = food consumption rate ($M_{prey,wet}/M_{pred,wet}$)

K'_i = chemical elimination rate (1/T)

In general, PCB concentrations in an organism was equal to the sum of the PCB uptake from water (across the gill) and from consumption minus the PCB concentrations lost through elimination (excretion and dilution through growth). Equations for the consumption rate, PCB uptake rate, and PCB excretion rate are fully described in “1992 MICHTOX: A Mass Balance and Bioaccumulation Model for Toxic Chemicals in Lake Michigan” (Endicott, 2005).

For phytoplankton, PCB accumulation was assumed to be a partitioning process, assuming 2% organic carbon composition on a wet weight basis. The PCB concentrations in detritus, the food source for benthic organisms, was assumed to be equal to that of the surficial sediment.

3.4.2 Description of the Data Used in MICHTOX Food Chain

3.4.2.1 Description of Data

Fish and lower food chain organism data used for MICHTOX modeling were collected in three biota zones (Figure 3.4.1) (McCarty *et al*., 2004). The biota zones were geographical areas on the lake chosen to compare and contrast the fish population characteristics in different regions of Lake Michigan.

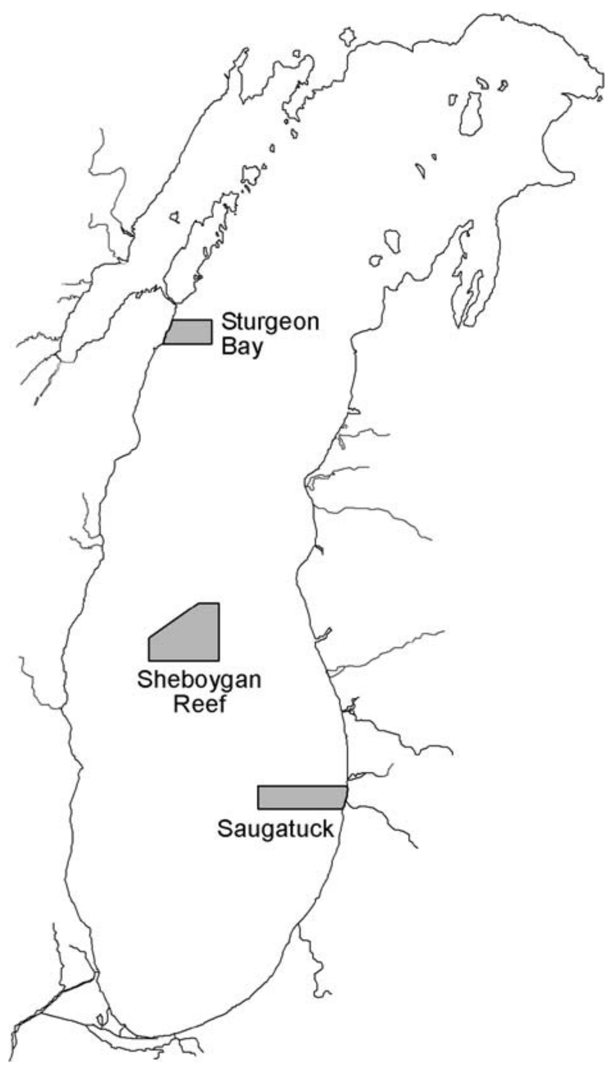

Figure 3.4.1. The LMMBP biota sampling zones.

The Saugatuck biota zone is located on the eastern side of Lake Michigan (MICHTOX water column segments 1 and 8). The Sturgeon Bay biota zone is located east of the Door Peninsula (MICHTOX water column segments 2 and 9). The Sheboygan Reef biota zone in southern Lake Michigan is located just south of the segment partition between MICHTOX water column segments 1 and 2. The Sheboygan Reef data are only shown for information purposes. Because forage fish were collected in a substantially different location than the lake trout at this site and were possibly not representative of prey items on the reef, the Sheboygan Reef data were not used for model confirmation. Tables 3.4.1, 3.4.2, and 3.4.3 show the biota data for their respective zones. In the higher trophic levels, it can be seen that Saugatuck organisms had a consistently higher amount of total PCB concentrations than organisms at other locations (Figure 3.4.2).

The representation of the Lake Michigan food chain in the MICHTOX food chain modeling included five organisms: phytoplankton, *Mysis, Diporeia*, alewife, and lake trout.

3.4.2.2 Sources and Choice of Constants

For the most recent study, LMMBP data were used to update alewife growth rates and biota zone-specific lipid concentrations. In addition, biota zone-specific growth rates and biota zone-specific lipid concentrations were used for lake trout. The age- and species-specific weight, growth rate, and lipid concentrations for all organisms are shown in Table 3.4.4. Table 3.4.5 includes the food assimilation efficiencies and the chemical assimilation coefficients for the organisms and PCB homologs used in the MICHTOX food chain model.

3.4.3 Model Confirmation

In previous work with the MICHTOX model and the LMMBP data (Endicott, 2005), a hindcast confirmation of the MICHTOX fate and transport submodel and the food chain submodel was conducted to establish confidence in the model and model parameters. The hindcast simulations of both submodels were discussed in Part 3, Chapter 3.3. The food chain organism weights, specific growth rates, and lipid concentrations were subsequently

Table 3.4.1. Average Total PCB Concentrations in Fish in the Saugatuck Biota Zone

Species	Age (Years)	Average PCB Concentrations (ng/g)	PCB Standard Deviation (ng/g)
Alewife < 120 mm	1-2	304	167
Alewife > 120 mm	3-7	592	140
Lake Trout	1	175	
Lake Trout	2	904	171
Lake Trout	3	883	288
Lake Trout	4	1287	241
Lake Trout	5	2068	532
Lake Trout	6	3185	1126
Lake Trout	7	3609	809
Lake Trout	8	4511	921
Lake Trout	9	5728	1645
Lake Trout	10	8209	4101
Lake Trout	11	7477	2515
Lake Trout	12	8116	2997
Lake Trout	13	6666	872
Lake Trout	14	6799	794
Lake Trout	15	4014	3268

Table 3.4.2. Average Total PCB Concentrations in Fish in the Sheboygan Reef Biota Zone

Species	Age (Years)	Average PCB Concentrations (ng/g)	PCB Standard Deviation (ng/g)
Lake Trout	3	547	184
Lake Trout	4	706	217
Lake Trout	5	1202	204
Lake Trout	6	1395	192
Lake Trout	7	1974	320
Lake Trout	8	2668	1001
Lake Trout	9	3102	1022
Lake Trout	11	5322	1215
Lake Trout	12	4692	1234
Lake Trout	13	4466	217
Lake Trout	14	3483	

Table 3.4.3. Average Total PCB Concentrations in Fish in the Sturgeon Bay Biota Zone

Species	Age (Years)	Average PCB Concentrations (ng/g)	PCB Standard Deviation (ng/g)
Alewife < 120 mm	1-2	170	71
Alewife > 120 mm	3-7	589	171
Lake Trout	1	350	163
Lake Trout	2	395	107
Lake Trout	3	889	159
Lake Trout	4	1268	270
Lake Trout	5	1707	309
Lake Trout	6	2487	577
Lake Trout	7	2656	509
Lake Trout	8	3360	559
Lake Trout	9	4211	757
Lake Trout	10	5283	1168
Lake Trout	11	5939	1543
Lake Trout	12	4420	1185
Lake Trout	13	4324	438
Lake Trout	14	5254	1345
Lake Trout	15	7192	683

Table 3.4.4. MICHTOX Food Chain Age- and Species-Specific Weight, Growth Rate, and Lipid Concentrations

MYSIS

Age	Weight (g)	Growth Rate (1/day)	Lipid %
1	0.00021	0.0193	4
2	0.0022	0.0107	4
3	0.00811	0.0073	4
4	0.01977	0.0056	4

DIPOREIA

Age	Weight (g)	Growth Rate (1/day)	Lipid %
1	0.00007	0.00398	3
2	0.00300	0.00203	3
3	0.00630	0.00313	3

ALEWIFE

Age	Weight (g)	Growth Rate (1/day)	Average Lipid % Sheboygan Reef	Average Lipid % Saugatuck	Average Lipid % Sturgeon Bay
1	3	0.00441	7.2	5.5	4
2	15	0.00161	8.5	5.5	6
3	27	0.00086	9.0	6.0	6
4	37	0.00054	10.5	7.5	6
5	45	0.00029	11.5	9.0	6
6	50	0.00016	12.0	10.0	6
7	53	0.00010	12.2	11.0	6

STOCKED TROUT

Age	Weight (g) Sheboygan Reef	Growth Rate (1/day) Sheboygan Reef	Lipid % Sheboygan Reef	Weight (g) Saugatuck	Growth Rate (1/day) Saugatuck	Lipid % Saugatuck	Weight (g) Sturgeon Bay	Growth Rate (1/day) Sturgeon Bay	Lipid % Sturgeon Bay
1	20	0.005082	2.30	90	0.001898	2.30	98	0.000554	4.80
2	128	0.001766	3.66	180	0.003058	3.66	120	0.002931	4.68
3	244	0.001909	7.90	550	0.001898	7.13	350	0.002263	9.21
4	490	0.001665	9.36	1100	0.001704	9.52	800	0.001721	11.81
5	900	0.001166	12.48	2050	0.000902	14.77	1500	0.001609	17.04
6	1378	0.000879	15.56	2850	0.000483	18.96	2700	0.000465	18.30
7	1900	0.000859	18.60	3400	0.000445	21.05	3200	0.000397	19.13
8	2600	0.000734	19.36	4000	0.000322	18.56	3700	0.000474	20.52
9	3400	0.000445	19.34	4500	0.000499	19.12	4400	0.000350	20.15
10	4000	0.000261	19.10	5400	0.000508	20.68	5000	0.000261	22.63
11	4400	0.000181	20.73	6500	0.000164	22.00	5500	0.000049	22.50
12	4700	0.000114	22.40	6900	0.000078	23.00	5600	0.000096	20.53

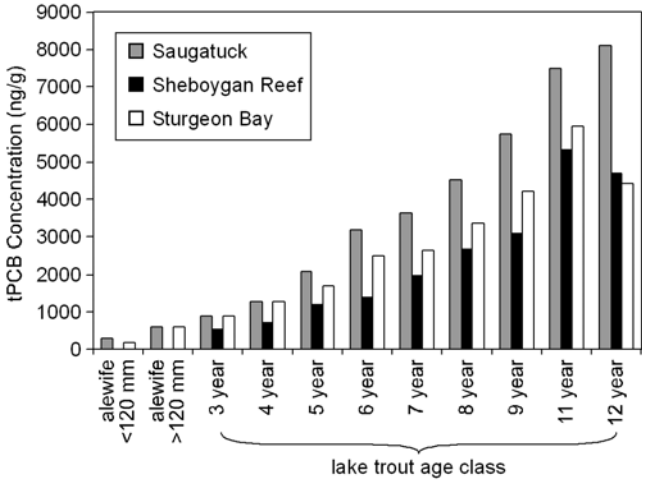

Figure 3.4.2. Total PCB concentrations of organisms in Lake Michigan biota zones.

Table 3.4.5. MICHTOX Food Chain Model Parameters and Coefficients

Parameter	Value (Unitless)
Mysis Assimilation of Ingested Food	0.400
Diporeia Assimilation of Ingested Food	0.0288
Alewife Assimilation of Ingested Food	0.800
Stocked Lake Trout Assimilation of Ingested Food	0.800
Mysis Chemical Assimilation (PCB4)	0.800
Diporeia Chemical Assimilation (PCB4)	0.405
Alewife Chemical Assimilation (PCB4)	0.800
Stocked Lake Trout Chemical Assimilation (PCB4)	0.600
Mysis Chemical Assimilation (PCB5)	0.575
Diporeia Chemical Assimilation (PCB5)	0.165
Alewife Chemical Assimilation (PCB5)	0.575
Stocked Lake Trout Chemical Assimilation (PCB5)	0.600

updated as described in Section 3.4.2. Estimates of unmonitored tributary PCB loads were also added. The hindcast model runs were repeated with the new food chain parameterization, and the results were again in general agreement with the available data.

While previous applications of MICHTOX used hindcast model runs to confirm model performance and evaluate past loading (Endicott *et al*., 2005; Endicott, 2005), the most recent application of the model focused on forecast model runs. For the latest study, the model performance representing Lake Michigan food chain PCB dynamics was confirmed by comparing forecast model predictions to lake trout data collected from the Saugatuck biota zone. The forecast confirmation model run was compared against the same Saugatuck biota zone historical lake trout data (1970 to 2002) as the hindcast runs previously described (DeVault *et al*., 1996; Swackhamer, 2003). For these studies, lake trout were collected in a specific size range with an average weight of 2,600 grams, which is approximately the average weight of the five year-old and six year-old lake trout at Saugatuck (Table 3.4.4) collected during the LMMBP. The average of the five year-old and six year-old lake trout will be referred to as “5.5 year-old” lake trout. The MICHTOX model was set up with Constant Conditions for the 1994-2050 time frame: vapor concentrations, tributary loadings, and atmospheric loads were repeated from those measured during 1994-1995. The original food chain model coefficients were found to give an acceptable fit between model and the 5.5 year-old lake trout total PCB data (Figure 3.4.3). Chemical assimilation efficiencies were adjusted to see if a better fit could be obtained, but no substantial improvement was obtained.

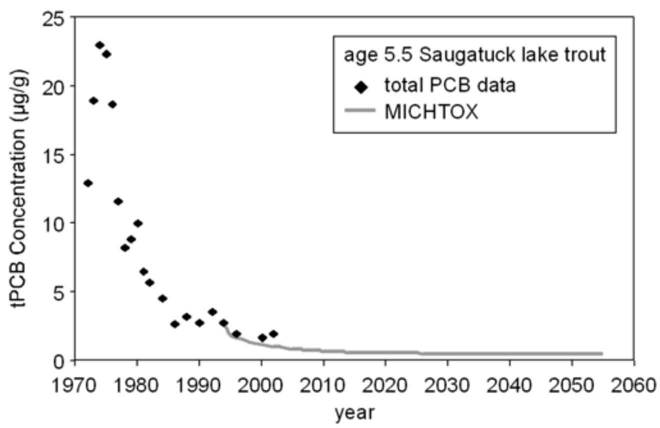

Figure 3.4.3. Total PCB concentrations in 5.5 year-old lake trout at Saugatuck biota zone.

3.4.4 Results – Forecast Scenarios

The ability to forecast future pollutant concentrations based upon changes in pollutant loadings is one of the most useful capabilities of models. MICHTOX was used to forecast the reduction in total PCB concentrations in the Lake Michigan food chain, especially those trophic levels that would impact human health risk by consumption such as lake trout.

The forecast simulations in Sections 3.4.4 and 3.4.5 were run for 62 years, from January 1, 1994 through December 31, 2055. Measured LMMBP PCB concentrations were used to define initial conditions in water, sediment, and fish (McCarty *et al.*, 2004). All simulations used the 1994-1995 forcing functions for the first two years of the model run. The forcing functions were determined from measured values of the LMMBP and included atmospheric vapor concentration, wet and dry atmospheric deposition loads, and monitored and unmonitored tributary loads. These forcing functions were the same as those used in the MICHTOX model run for Section 3.3.3.3 and were calculated in the same manner as the congener-specific functions of the LM2-Toxic model. The calculation procedures are described in Sections 4.4.3.1 and 4.6.3. After January 1, 1996, forcing functions were varied according to the specified conditions of the forecast scenario.

The scenario results were evaluated against a fish advisory consumption guideline target level for the total PCB body burden in lake trout. The Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory (Great Lakes Sport Fish Advisory Task Force, 1993) derived a target concentration in the edible portion of lake trout of 0.05 ppm. For comparison to the LMMBP model output, this value was converted to a whole fish concentration of 0.075 µg total PCBs/g fish (Appendix 3.4.1). Model output for the average of five and six year-old lake trout ("5.5 year-old fish") was selected for evaluation against the target level to be consistent with the size range of fish in the long-term data set (DeVault *et al.*, 1996).

In this section, MICHTOX was applied to three loading scenarios. The first scenario assumed constant loads at the 1994-1995 level. The second and third scenarios had decreasing loads based upon decline rates observed in the literature. The results of the scenario simulations for Saugatuck are displayed in Figures 3.4.4a and 3.4.4b, and the Sturgeon Bay results are displayed in Figures 3.4.5a and 3.4.5b. The figures include an expanded concentration scale to allow a comparison of predicted total PCB concentrations to the 0.075 µg total PCBs/g fish consumption advisory target concentration. While the model results are referenced to data from the Saugatuck and Sturgeon Bay biota zones, MICHTOX has relatively coarse segmentation and the model results only represent the southern and middle sections of Lake Michigan.

3.4.4.1 Conditions Remain the Same as 1994-1995 (Constant Conditions)

For this scenario, 1994-1995 forcing functions (tributary loads, atmospheric deposition loads, and atmospheric vapor concentrations) were assumed to remain constant from January 1, 1994 through December 31, 2055. The two-year cycle of forcing functions was repeated for the entire 62-year period of the scenario. This scenario provides insight into the equilibrium status of the system to the 1994-1995 conditions, but it likely overestimates future

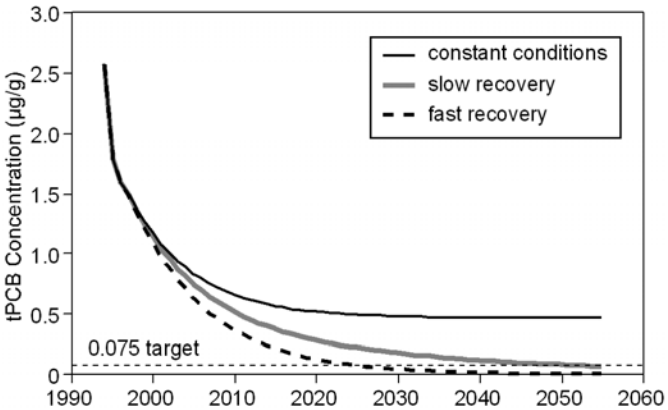

Figure 3.4.4a. Sensitivity scenario predicted total PCB concentrations in 5.5 year-old lake trout from Saugatuck biota zone.

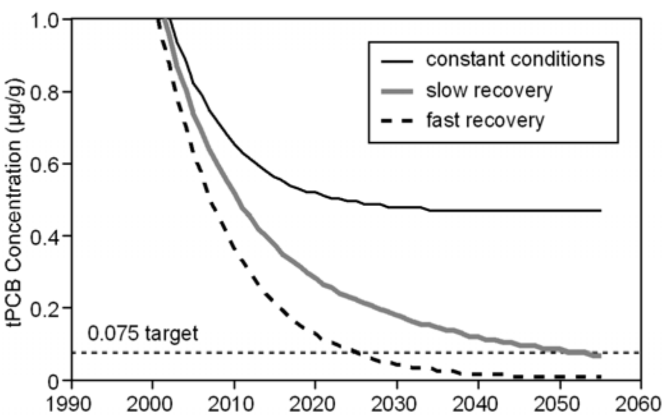

Figure 3.4.4b. Sensitivity scenario total PCB predictions and the fish consumption target level.

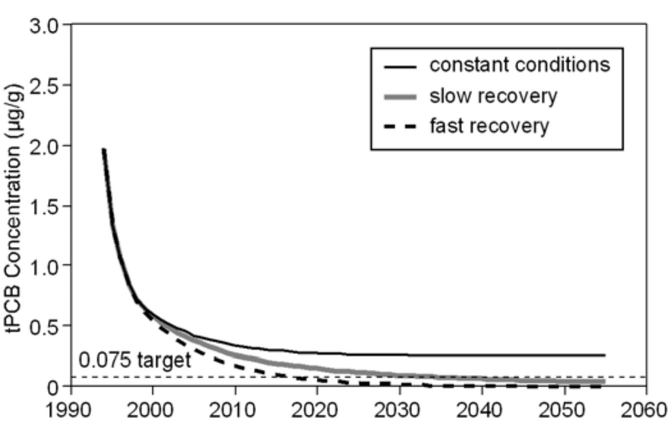

Figure 3.4.5a. Model application scenario total PCB predictions in 5.5 year-old lake trout from the Saugatuck biota zone.

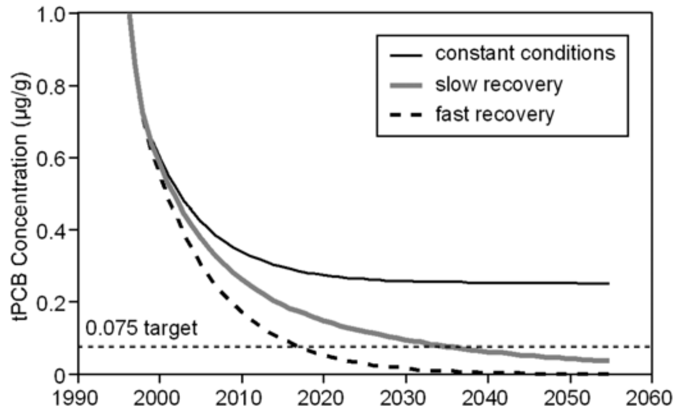

Figure 3.4.5b. Application scenario total PCB predictions and the fish consumption target level.

concentrations because current declining trends of forcing functions resulting from historical clean-up efforts were not taken into account.

The 5.5 year-old lake trout total PCB concentrations decreased until reaching approximate steady-state concentrations of 0.47 µg/g at Saugatuck and 0.25 µg/g at Sturgeon Bay (Figures 3.4.4a and 3.4.5a) in roughly 40 years. The initial decline in lake trout concentrations suggests that the 1994-1995 state of the Lake Michigan system was not in equilibrium with previous PCB reduction efforts. Total PCB concentrations in 5.5 year-old lake trout at both sites were significantly above the 0.075 µg total PCBs/g fish consumption advisory target (Figure 3.4.4b and 3.4.5b), and reductions in 1994-1995 loads and concentrations would be necessary to achieve the target fish concentrations.

3.4.4.2 Continued Recovery – Fast

This scenario simulated total PCB concentrations in lake trout as the system responded to declines in PCB loads and atmospheric concentrations. This scenario assumed that the faster of the observed decline rates of PCB loadings (Section 1.7.2) will continue for the entire 62-year simulation period. Forcing functions were assumed to decrease from 1994-1995 levels at a six-year half-life for atmospheric components (vapor phase PCB concentrations and wet and dry atmospheric deposition loadings) and a 13-year half-life for PCB tributary loadings).

Total PCB concentrations in lake trout were predicted to decrease at an exponential rate (Figures 3.4.4a and 3.4.5a). Total PCB concentrations in 5.5 year-old lake trout were predicted to be less than the 0.075 µg total PCBs/g fish consumption advisory target concentration in the year 2025 for Saugatuck and 2018 for Sturgeon Bay (Figures 3.4.4b and 3.4.5b).

Recent studies (Buehler *et al.*, 2002) have suggested that historical rates of decline have recently slowed, and thus this scenario, while realistic, may overestimate the future rate of decline.

3.4.4.3 Continued Recovery – Slow

This scenario also simulated the system response to declines in PCB loads and atmospheric concentrations, but assumed that a slower observed decline rate of PCB loadings (Section 1.7.2) will continue for the 62-year simulation period. Forcing functions were assumed to decrease from 1994-1995 levels at a 20-year half-life for atmospheric components (vapor phase PCB concentrations and wet and dry atmospheric deposition loadings) and a 13-year half-life for PCB tributary loadings).

Total PCB concentrations in lake trout again declined exponentially but at a slower rate than in the previous scenario (Figures 3.4.4a and 3.4.5a). Total PCB concentrations in 5.5 year-old lake trout were predicted to take 28 years longer to reach the consumption advisory target concentration at Saugatuck. The 0.075 µg total PCBs/g fish target concentration was achieved in the year 2053 for Saugatuck and 2037 for Sturgeon Bay (Figures 3.4.4b and 3.4.5b).

The atmospheric vapor and deposition decline rate selected for this scenario was on the conservative side of possible rates, and the predicted dates of compliance with the consumption advisory target are likely the upper bound of possible dates.

3.4.5 Model Sensitivity

Four model sensitivity runs were conducted to analyze the importance of different total PCB loading sources to the Lake Michigan system. Each sensitivity run eliminated one or more loading sources to determine the impact of the sources on PCB concentrations in the water and lake trout. The remaining loading sources repeated the 1994-1995 values, similar to the constant conditions scenario. The loading sources removed included all tributary loads, atmospheric deposition loads, the combination of tributary and atmospheric deposition loads, and internal loads from the sediment. Results were displayed for the Saugatuck area, but the trends were similar for all areas of the main lake.

3.4.5.1 No Atmospheric Wet and Dry Deposition Loadings

This simulation analyzed the sensitivity of MICHTOX to the elimination of atmospheric wet and dry deposition loadings. The first two years of the simulation used the 1994-1995 forcing functions. After January 1, 2005, the atmospheric deposition loadings were set to zero for the remaining 60 years of the model run. The remainder of the forcing functions repeated the two-year 1994-1995 values.

The 5.5 year-old lake trout total PCB concentrations decreased at a rate considerably faster than the Constant Conditions Scenario and achieved a significantly lower steady-state concentration (Figure 3.4.6). The scenario with no atmospheric deposition was predicted to reach an approximate steady-state total PCB concentrations in lake trout of 0.30 µg/g, compared to the constant conditions steady-state concentration of 0.47 µg/g.

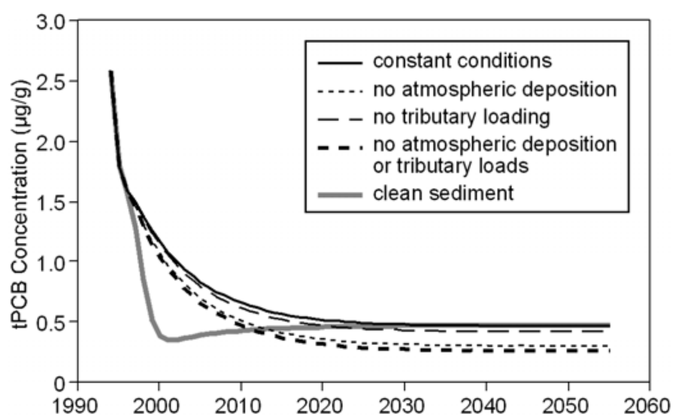

Figure 3.4.6. Sensitivity scenario total PCB concentration predictions for 5.5 year-old lake trout at Saugatuck.

3.4.5.2 No Tributary Loadings

This simulation analyzed the sensitivity of MICHTOX to the elimination of total PCB tributary loads to the Lake Michigan system. The first two years of the simulation used the 1994-1995 forcing functions, but after January 1, 2005, the tributary loadings were set to zero for the remainder of the model run. All other forcing functions repeated the two-year 1994-1995 values.

Compared to the Constant Conditions Scenario, the 5.5 year-old lake trout total PCB concentrations declined faster and reached a lower steady-state concentration, but the reduction was small (Figure 3.4.6). The scenario with no tributary loadings reached an approximate steady-state total PCB concentrations of 0.42 µg/g, compared to the constant conditions steady-state concentration of 0.47 µg/g.

Based upon these results, the system is predicted to have a greater sensitivity to wet and dry atmospheric deposition loadings than to tributary loadings. This result was not surprising, because MICHTOX treats tributary loadings and atmospheric deposition loadings in the same manner and the atmospheric deposition loadings were more than 2.6 times greater than tributary loadings in 1994-1995.

However, the relative magnitudes of tributary and atmospheric deposition loads were confounded by the available load estimate methodologies. The atmospheric deposition loads included estimates of the coarse particle loads, which were not directly measured. While comprising a large portion of the total load, the estimate of the coarse particle load is only approximate and may be subject to significant error.

The results of this scenario do not suggest that tributary loadings are not important. While they have a relatively small impact when looking at Lake Michigan on a large scale, such as MICHTOX does, tributary loadings have a large impact on the local receiving waters which they enter. Tributary loadings and their watershed sources may also have a significant effect on atmospheric vapor concentrations and deposition to the lake. Thus, clean-up of watershed PCB sources may have an effect on loadings which are not directly quantified by the water quality model.

3.4.5.3 No Atmospheric Deposition and No Tributary Loadings

This simulation combined the removal of tributary loadings and atmospheric deposition loadings. The first two years of the simulation used the 1994-1995 forcing functions. After January 1, 2005, the atmospheric deposition loadings and the tributary loadings were set to zero. Other forcing functions repeated the 1994-1995 values throughout the simulation period.

The 5.5 year-old lake trout total PCB concentrations decreased at a rate and achieved a steady-state concentration only slightly below those of the scenario with only atmospheric deposition loads removed (0.25 µg/g versus 0.30 µg/g) (Figure 3.4.6). As with the previous two scenarios, this suggested that atmospheric components had a greater effect on MICHTOX-predicted total PCB concentrations in Lake Michigan lake trout than tributary loadings.

3.4.5.4 Sediment Total PCB Concentration Initial Conditions Set to Zero

This scenario was conducted to evaluate the sensitivity of the total PCB concentrations in lake trout to the reservoir of total PCBs in the sediment of Lake Michigan. Measured LMMBP PCB concentrations were used to define initial conditions in water, sediment, and fish (McCarty *et al*., 2004). The 1994-1995 forcing functions were repeated for the entire period of the model run. On January 1, 1996, the sediment total PCB concentrations were re-set to zero, after which the model simulation was allowed to run normally for a 60-year period.

The shape of the lake trout PCB concentration curves over time was influenced by PCB dynamics in the water column and sediments and a time lag in the MICHTOX food chain. Water column concentrations dropped for two years as PCBs in the water column settled out and volatilized faster than loadings entering the system. After two years, however, water column concentrations began to recover due to tributary and atmospheric deposition loadings, resuspension of newly contaminated sediments, and absorption of PCBs from the atmosphere.

While the lower levels of the food chain immediately responded to the reduced PCBs in water and sediment, the higher food chain organisms had a residual body burden, and the response was slower. MICHTOX predicted a drop in the 5.5 year-old lake trout total PCB concentrations for a period of six years, then the concentrations steadily increased until reaching the same steady-state concentration as the Constant Conditions Scenario (Figure 3.4.6). The lake trout total PCB concentrations were within 5% of the concentrations of the Constant Conditions Scenario within a period of 30 years, and reached steady-state concentration about 45 years after the sediment clean-up. This was about the same time period required for the Constant Conditions Scenario to reach steady-state concentrations.

This scenario demonstrated the importance of the reservoir of total PCBs in the sediments on the total PCB concentrations in the higher levels of the food chain. Response time would be greatly influenced by the sediment settling and resuspension dynamics in the model.

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